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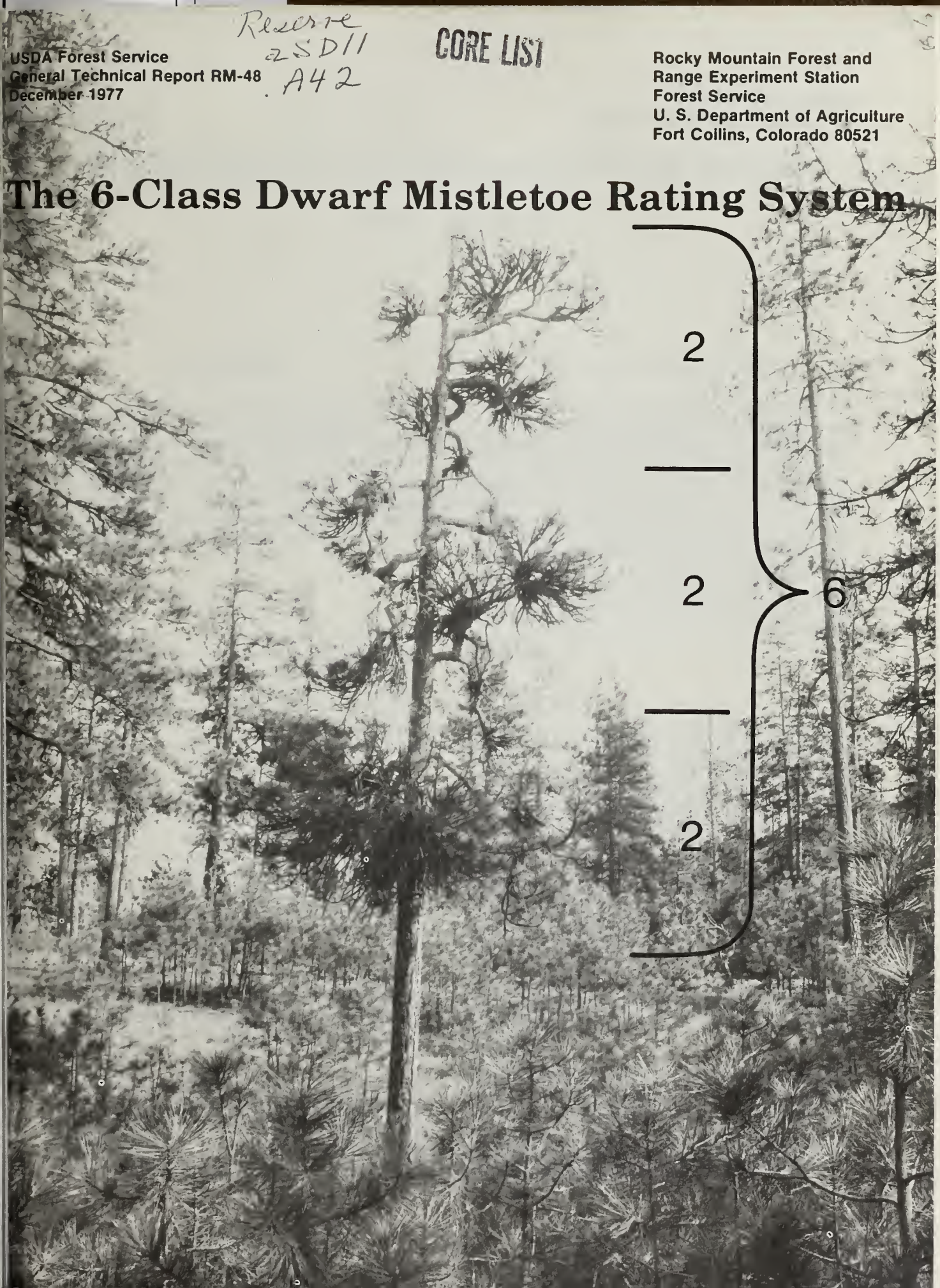
The 6-Class Dwarf Mistletoe Rating System



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The 6-Class Dwarf Mistletoe Rating System

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Abstract

Several rating systems have been proposed to describe the intensity of dwarf mistletoe infection in individual trees or stands, but the 6-class dwarf mistletoe rating (DMR) system, described in 1956, has been most widely adopted. This system is being used for several dwarf mistletoe host/parasite combinations in western North America. Uses and limitations of the 6-class system are discussed, and several applications of the system are cited.

[1] *Central headquarters maintained at Fort Collins in cooperation with Colorado State University.*

The 6-Class Dwarf Mistletoe Rating System

Frank G. Hawksworth

Introduction

During the period since the introduction of the 6-class dwarf mistletoe rating sytem (Hawksworth and Lusher 1956), it has become the generally accepted standard in the western United States and western Canada. This paper discusses dwarf mistletoe rating systems in general, the 6-class system in detail, and the uses and limitations of the 6-class system.

Rating Systems

Dwarf mistletoe rating systems are useful to: (1) quantify the degree of infection so that stand management priorities can be established, (2) aid quantification and estimation of growth loss and mortality, (3) help define which trees are suitable for seed trees, and (4) help quantify the mistletoe-infection hazard of overstory trees or stands to understory stands.

There have been several attempts to quantify dwarf mistletoe intensity on a tree basis (table 1). Some of these systems have used as few as 4 classes (including uninfected trees) and one as many as 18. In many of these classifications, and indeed in many dwarf mistletoe publications, infection intensity is rated as "light," "medium" or "heavy," but these terms have not been defined.

Some of the classification systems attempt to quantify the proportion of the crown broomed, others quantify the proportion of crown infected, while some utilize a combination of both types.

This plethora of rating systems makes it impossible to directly compare results of different studies. Thus, the 6-class system was designed to fill the need for a more uniform, less subjective, rating system.

The 6-Class Rating System

The 6-class dwarf mistletoe rating system was first used in 1951. It was first mentioned as a footnote in a paper by Hawksworth and Lusher (1956) and later described in more detail by Hawksworth (1961, p. 77) and Baranyay and others (1971). The system has six intensity classes of mistletoe infection plus one for noninfected trees. For this reason perhaps it should have been referred to as the "7-class" system. However, since the name "6-class" has been widely used in the literature for many years and has not been the source of confusion, I suggest continuance of the "6-class" designation.

Description

For this system the live crown is divided into thirds, and each third is rated as: 0, no mistletoe; 1, light mistletoe (less than half of the branches infected); and 2, heavy mistletoe (more than half of the branches infected). The ratings of each third are added to obtain a total for the tree. For example, a tree heavily infected in the lower third of the crown, lightly infected in the middle third, and not infected in the upper third, would be Class 3. A tree heavily infected in each third would be Class 6 (fig. 1). The system is simple to use, and different observers tend to rate an infected tree similarly.

A tree with an infection on the bole, but not the branches, is rated as Class 1. Otherwise, bole infections are not considered in the rating system.

Abbreviations which will be used in this paper are DMR, for a tree rating using the 6-class system, and $\overline{\text{DMR}}$ for a stand rating.

The 6-class system was originally used for *Arceuthobium vaginatum* subsp. *cryptopodum*

Table 1.—Rating systems used for dwarf mistletoe-infected trees

Arceuthobium species (and host)	Number of classes (including healthy)	Description	Reference
A. laricis (western larch)	5	0, healthy trees; infected rated X, XX, XXX, or XXXX based on degree of infection (not defined).	Weir 1916
A. vaginatum subsp. *cryptopodum* (ponderosa pine)	4	0, healthy trees without mistletoe; X, light mistletoe infection; XX, medium mistletoe infection; XXX, heavy mistletoe infection.	Korstian and Long 1922
A. americanum (jack pine)	4	0, healthy tree; X, slightly infected tree; XX, severely infected tree; XXX, very badly broomed tree.	Dowding 1929
A. douglasii (Douglas-fir) and *A. vaginatum* subsp. *cryptopodum* (ponderosa pine)	7	Six class system. Each third of a live crown rated as 0, no mistletoe; 1, less than half the branches infected; or 2, more than half the branches infected. Ratings of each third totaled for this rating. Ratings range from 0 (uninfected tree) to 6 (heavily infected). (Described in more detail in this paper).	Hawksworth and Lusher 1956, Hawksworth 1961
A. douglasii (Douglas-fir) and *A. laricis* (western larch)	4	"None" - No visible infection; "Light" - less than one-third of crown broomed; "Medium" - one to two thirds of crown broomed; "Heavy" - more than two-thirds of crown broomed.	Pierce 1960
A. douglasii (Douglas-fir)	4	Class I - No evidence of brooming; Class II - brooming confined to lower third of live crown; Class III - brooming for at least two-thirds of live crown; Class IV - brooming for at least two-thirds of live crown, and spike top developing.	Shea 1963
Arceuthobium spp. (several hosts in western Montana)	5	Live crown divided into 2 equal parts, each half was rated as 0, no infection; 1, less than one-third of branches infected; or 2, more than one-third of branches infected. Total for each half of crown added for tree totals which range from 0 (no infection) to 4 (very heavy infection).	Graham 1964
Arceuthobium spp. (several hosts in NE Washington)	6	Same as above, but with 1 additional class for trees killed within the previous 5 years and showing symptoms or signs of having had dwarf mistletoe.	Graham and Frazier 1962
A. tsugense (western hemlock)	18	Each third of crown rated from 0.0 (no visible infections) to 3.0 (numerous large branch infections in the form of witches' brooms and at least one trunk swelling) by 0.5 class intervals. Rating in each third totaled for tree ratings.	Smith 1969
A. tsugense (western hemlock)	6	Middle-third rating system. Because the lower third of the tree often had numerous dead, broken, and missing branches and because the top third was often partially hidden, an analysis of growth loss in relation to the middle-third rating only was made. The results suggest that middle-third rating is superior to whole-tree rating.	Smith 1969

Arceuthobium species (and host)	Number of classes (including healthy)	Description	Reference
A. americanum (lodgepole pine)	4	0, healthy; 1, light branch infection, less than 50% of crown infected; 2, heavy branch and stem infection, more than 50% of the crown infected; 3, witches' brooms, branch and stem infections, more than 50% of the crown infected.	Baranyay and Safranyik 1970
A. abietinum (true firs)	10	Each third of crown rated as 0, no mistletoe; 1, 1-10% of branches infected; 2, 11-50% of branches infected; and 3, over 50% of branches infected. Totals added for tree rating. Note that by combining classes 1 and 2 in each third, ratings are the same as in the 6-class system.	Scharpf 1977

in ponderosa pine and for *A. douglasii* in Douglas-fir in the Southwest (Hawksworth and Lusher 1956, Andrews and Daniels 1960, Hawksworth 1961). It was later found to be applicable to *A. americanum* in lodgepole pine in the Central Rockies (Hawksworth and Hinds 1964, Myers and others 1971). The system has also been applied to *A. campylopodum* in ponderosa pine in the Pacific Northwest (Shea 1964, Flora 1966), *A. occidentale* in Digger pine in California (Hawksworth 1969), and *A. cyanocarpum* on limber pine in Colorado (Hawksworth and others 1975).

The 6-class system is also being widely used in western Canada: in British Columbia for *A. americanum* in *Pinus contorta* (Dobie and Britneff 1975), *A. tsugense* in *Tsuga heterophylla* and *Pinus contorta* var. *contorta* (Smith and Wass 1976), and *Arceuthobium* spp. (Baranyay and Smith 1972).

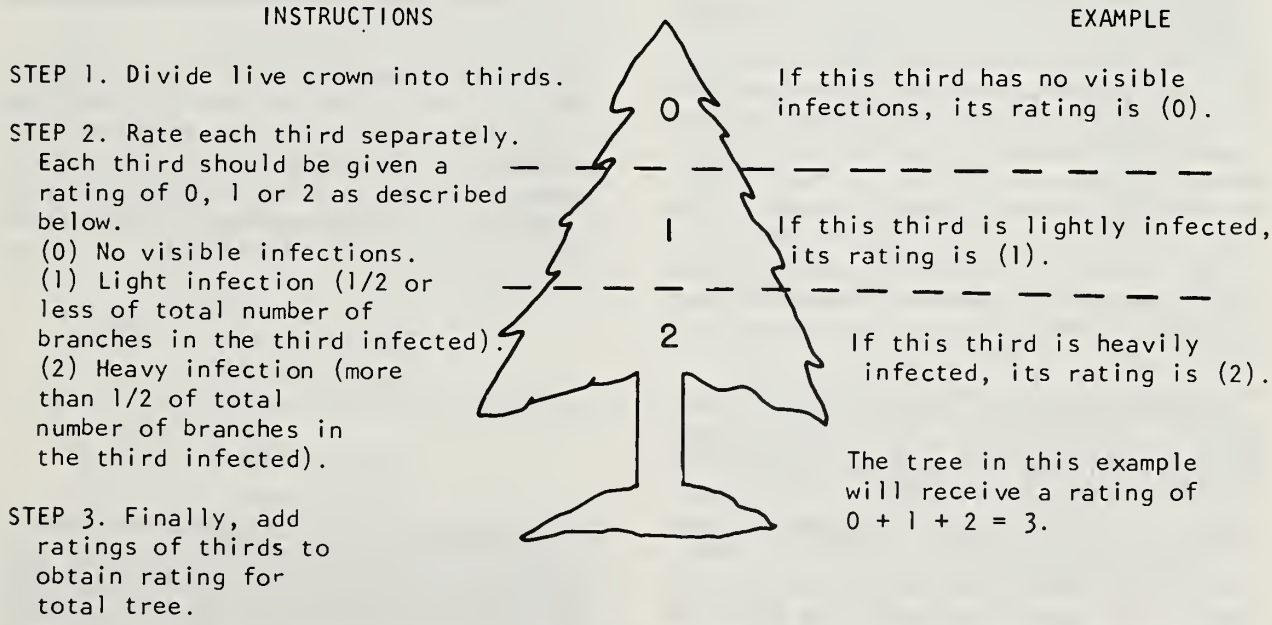

Figure 1—The 6-class mistletoe rating system [Hawksworth 1961].

The 6-class system has been questioned since it does not directly consider the degree of brooming in rating a tree. However, the degree of brooming is indirectly considered because frequency of brooming is directly correlated with the infection class. As shown in the following example for *A. vaginatum* subsp. *cryptopodum* on southwestern ponderosa pine, the proportion of trees broomed increases markedly as the infection class increases (Hawksworth 1961).

DMR	Broomed trees as percent of trees infected
1	3
2	4
3	16
4	36
5	61
6	68

Growth of moderately or heavily broomed trees is more adversely affected than growth of the non- or slightly broomed trees of the same class (Hawksworth 1961). The above tabulation shows that, when trees are grouped by infection classes, the brooming is accounted for because brooming is related to infection class. No comparable data are available for other host/parasite combinations, but the relationship is probably similar for them.

The 6-class system has also been criticized because it sometimes tends to overrate lightly infected trees. For example, a tree with two infections—one in the lower third and one in the middle third of the crown—would be rated as Class 2, whereas a tree of comparable size may have several infections and still be rated only as Class 1 if they are all in the same third, and less than half the branches in that third are infected. Scattered infections, however, rarely occur throughout the crown. Infection normally takes place first in the lower third of the crown and spreads upward. A Class 2 tree typically has only the lower third of the crown infected; Class 3, the lower half; Class 4, the lower two-thirds, etc.

In the 6-class system, dwarf mistletoe in each third of the crown is given equal weight. However, the actual crown volume in each third of a tree is normally not the same—that is, the volume of the lower third is usually greater than the upper third. This is somewhat offset, however, by the fact that mistletoe in the lower third of the crown has much less effect on growth of the tree than the same amount of infection in the upper third. For this reason, and because it would complicate the rating system and make it more difficult to apply, unequal weighting by thirds probably would not be useful on a practical basis.

Most analyses of $\overline{DMR}$ on a stand basis have been in even-aged or two-aged stands. In these cases, $\overline{DMR}$ for the stand or story adequately describes the mistletoe situation. However, average $\overline{DMR}$ may not be as meaningful for all-aged, irregular stands, and a $\overline{DMR}$ based only on the dominant trees may be needed.

Limitations

The 6-class system can be applied to trees of any size class, but in practice it is difficult to use for very small trees.[2] Specifically, it is not recommended for trees under about 10 feet tall. Application of the system is also difficult for small, suppressed trees with sparse crowns, or for dense pole-sized trees with very short crowns. Since such trees usually constitute only a small proportion of a stand, however, the overall results on a stand basis are usually little affected if the system is applied to these trees.

The 6-class, or any system that requires rating tops of trees, also may not be practical in dense stands of very tall trees. For example, Smith (1969) found it difficult to examine the tops of trees in dense western hemlock stands in coastal British Columbia, so he devised a rating system based only on the amount of infection in the middle third of the crown.

The 6-class system is useful in evaluating the effects of the parasite on growth of infected trees, but it does not necessarily provide a measure of the infection potential of a tree. For example, a Class 6 tree may be of such poor vigor that it is producing fewer mistletoe seeds than a more vigorous Class 2 tree.

[2] *A modification used for small lodgepole pines in interior British Columbia is to divide the crown in thirds in the usual manner but to rate intensity on number of infections rather than proportion of branches infected, e.g. one to three infections in each third would rate a "1", and four or more infections would rate a "2". Personnel communication, Allan Van Sickle, Pacific Forest Research Centre, Victoria, B.C., 1977.*

Table 2.—Distribution of dwarf mistletoe by classes and average stand ratings for 41 even-aged lodgepole pine plots (0.02 to 0.43 acre) in Colorado and Wyoming (Data from research reported by Myers et al. 1971)

Plot $\overline{DMR}$ range	No. of plots	Observed average plot $\overline{DMR}$	Distribution of trees by DMR classes						
			0	1	2	3	4	5	6
			Percent						
0.1 - 1.0	10	0.1	95	3	1	1	0	0	0
1.1 - 2.0	5	1.5	47	15	11	13	9	4	1
2.1 - 3.0	9	2.8	8	14	18	30	18	8	4
3.1 - 4.0	6	3.5	3	6	11	27	31	16	6
4.1 - 5.0	7	4.6	1	2	5	12	20	30	30
5.1 - 6.0	4	5.3	1	1	3	5	10	17	63

Application of The 6-Class System

The primary use of the 6-class system is to quantify the intensity of infection in stands. For the stand average $\overline{DMR}$, the DMR's of each live tree (including healthy ones) are totaled and divided by the number of trees. Table 2 shows how the tree and stand $\overline{DMR}$'s were related for several lodgepole pine plots.

The detail of the 6-class system is not always needed, and classes may be combined. For example, Classes 1 and 2 ("light infection"), 3 and 4 ("moderate infection") and 5 and 6 ("heavy infection") were used by Shea (1964) in a study of the effects of dwarf mistletoe on diameter growth of ponderosa pine in Oregon. When it is necessary to document long-term intensification of dwarf mistletoe in a stand, the full classes should be retained.

Rating individual trees can be time-consuming when a great many trees need to be tallied, so short-cut methods to estimate $\overline{DMR}$ from the percentage of trees infected have been developed for some host/parasite combinations in some types of stands. The relationship between $\overline{DMR}$ and percentage of trees infected has been determined:

1. For lodgepole pine in the Central Rocky Mountains (Myers and others 1971)[3].
   $\log \overline{DMR} = -0.8814 + 0.01492\ P$
   P = percent of trees infected.
2. For ponderosa pine in the Southwest (Myers and others 1976).
   $\log \overline{DMR} = -0.9465 + 0.0165\ P$
   P = percent of trees infected

These equations are for unmanaged stands; they may or may not be applicable in stands that have been thinned, depending on how much consideration was given to mistletoe in marking. It is emphasized that these equations are only approximations and do not account for stand-to-stand variability. Hence, data based on actual $\overline{DMR}$ is more accurate and should be used if available.

[3] *Note: the original published equation is in error.*

Examples of 6-Class System Application

Some examples of how the 6-class system has been used on a tree basis are:

1. To document the growth rate of trees in different infection classes. The last 5 years d.b.h. radial growth in 140-year old, dominant ponderosa pines in relation to DMR was as follows. Mescalero Apache Reservation, New Mexico (Hawksworth 1961.)

DMR	Radial growth *(inches)*	Growth Rate (as a percent of average rate in classes 0-3)
0	0.21	100
1	.21	100
2	.21	100
3	.21	100
4	.19	90
5	.16	76
6	.10	48

2. To document the recurrence of mistletoe in trees pruned to control the parasite. Trees of higher infection classes developed so much mistletoe after pruning that they could not be repruned and had to be killed. Ponderosa pine, Grand Canyon National Park, Arizona (Lightle and Hawksworth 1973).

Original DMR	Percent of trees still alive after 20 years
1	70
2	50
3	40
4	10

Thus, it was concluded that most pruning should be confined to trees of infection Class 1.

3. Dwarf mistletoe is known to adversely affect seed population of the host tree. In the case of ponderosa pine, it is suggested that suitable seed must be of DMR 3 or lower (Myers 1974).

Examples of the use of $\overline{DMR}$ for prediction are:

4. 10-year mortality in even-aged ponderosa pine stands in the Southwest (Myers and others, 1976):

$Y = 20.665 + 4.423X_1 - 0.364X_2 + 3.876X_3$ when,

Y = 10-year mortality in trees per acre

$X_1 = \overline{DMR}$

X_2 = site index (base age 100)

X_3 = number of trees per acre.

5. 10-year periodic height increase in infested stands as a proportion of increase in comparable uninfested stands (Myers and others 1971).

$Y = 1.0 - 0.165X_1$

Y = height decrease proportion.

$X_1 = \overline{DMR}$

Conclusions

Of the 12 dwarf mistletoe rating systems proposed, the 6-class system is most widely used. It is being used for several host/parasite combinations in the western United States and Canada. The 6-class system has been used for many purposes, e.g., to quantify height and diameter growth loss in infected trees; to quantify infection in stands; and to indentify which trees are suitable as seed trees. The system does not, however, necessarily provide a measure of infection potential of a tree as this is frequently not related to the amount of infection in a tree. Thus, while it is recognized that the 6-class system has some limitations and may not be applicable to all host/parasite combinations, it does have the strong attribute of comparability and seems to be the best currently available system for general use.

A description and example of the use of the 6-class system in a plastic coated, wallet-size card has been prepared by the Southwestern Region. These are available from the author or from:

USDA Forest Service
Forest Insect and Disease Management
517 Gold Avenue, S.W.
Albuquerque, N.Mex. 87102

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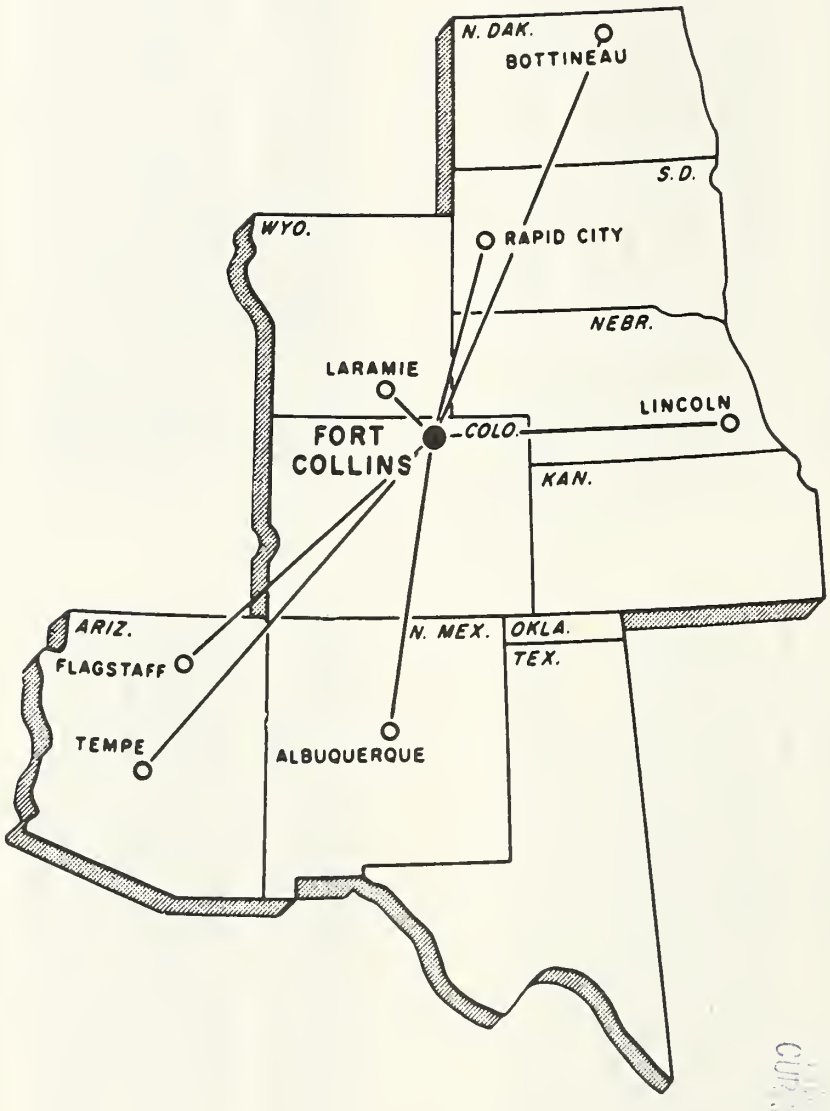

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